

and at last to red-brown, the colour of oxide; it loses in average 8 to 9 per cent. sulphuric acid with combined water. When dissolved in boiling hydrochloric acid a snow-white residuum is obtained, which, under the microscope, proves to be composed of extremely well-preserved shells of microscopic Radiolaria, belonging to different genera. The size of those mostly regular globular bodies ranges between 0.045 millim. and 0.1135 millim. The quantity of this residuum amounts in a mean of three trials to 25 per cent. The quantity of soluble substance is therefore 73 per cent., if we take away 2 per cent. hygroscopic water. This soluble substance is pure sulphate of oxide of iron with a very small amount of sulphate of alumina. The quantity of the sulphuric acid in the mineral was directly determined by precipitation of the hydrochloric solution of the mineral with chloride of barium. 2,000 mgrms. of the mineral gave 1,250 mgrms. sulphate of baryta, corresponding to 431 mgrms. sulphuric acid. The amount of this acid in the mineral is therefore 21.5 per cent. The quantity of the oxide with a small amount of alumina is 51.5 per cent., corresponding to 36 per cent. metallic iron.

No traces of copper or any other metal have been found in the mineral; a trace of arsenic, however, is observed, as is shown by means of the copper-arsenic test, by boiling the hydrochloric solution with a clean copper slip, which becomes coated with a thin deposit of metallic arsenic.

Cyprusit is composed as follows:—

Oxide of iron, with a very small amount of alumina	51.5
Sulphuric acid	21.5
Insoluble siliceous substance	25
Hygroscopic water	2
	100.0

- V. "On certain points in the Anatomy of Chiton." By ADAM SEDGWICK, M.A., Fellow of Trinity College, Cambridge. Communicated by F. MAITLAND BALFOUR, F.R.S. Received November 5, 1881.

An account of the structure of the kidney of Chiton has long been a want in morphology. Middendorff,* in 1848, described a branched gland lying ventrally on each side of the body cavity which he identified as kidney; but he records no observation on the structure of the objects belonging to natural history derived from Cyprus I add a new one; the mineral would bear the name "Cyprusit."

* "Mémoires de l'Acad. de St. Pétersbourg," 6th ser., vol. vi.

gland, and expressly states that he was not able to make out its opening or relation to other organs. Schiff,* ten years later, was unable to find this gland in *Chiton piceus*, and throws doubt on Middendorff's interpretation of its function.

Von Jehring† has comparatively recently recorded some observations on the kidney of *Chiton*, and starts from the position that no kidney is known in *Chiton*, Middendorff's view as to the nature of the branched gland having been sufficiently refuted by Schiff's later observations. Von Jehring states that in the species of *Chiton* observed by him, the kidney consists of a branched gland lying ventral to the rectum in the hinder part of the body cavity, and that it opens by a single median pore ventral to the anus. He further figures this opening.

While staying at Herm this summer I found a fair number of a good-sized species of *Chiton*—*Chiton discrepans*; and the results which I have obtained from the study of the anatomy of this form, especially those which concern the kidney, seem to me sufficiently important for immediate publication. In the first place, I may mention that I have seen nothing in any of my dissections or sections which in the least supports von Jehring's statements as to the existence of a median renal duct and opening; and that my observations are entirely opposed to the conclusion arrived at by this investigator as to the unpaired nature of the kidney of *Chiton*. On the contrary, Middendorff's observations, so far as they went, were perfectly correct. The paired lateral branched gland described by the latter observer is part of the kidney.

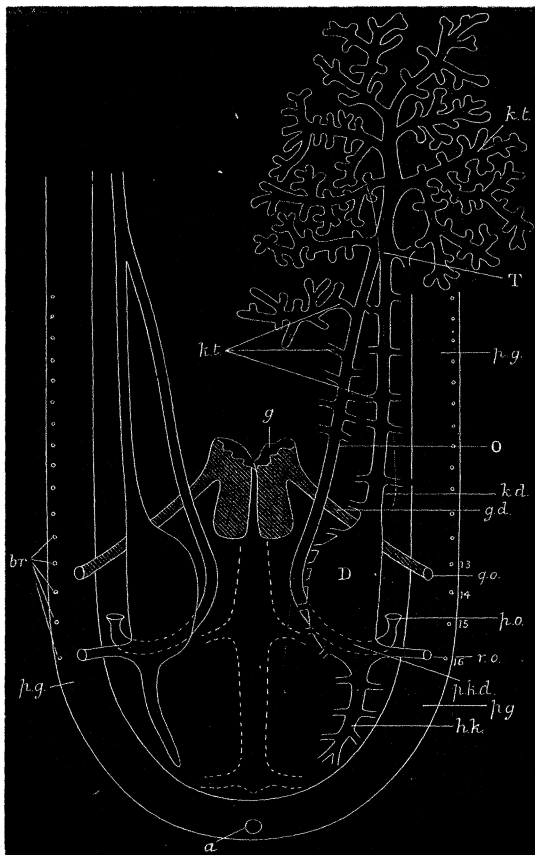
The kidney of *Chiton* is a paired gland with paired openings into the pallial groove and into the pericardium, and is constructed on the type always found in molluscan renal organs (fig. 1). It opens in the species I have chiefly examined (*Chiton discrepans*) into the pallial groove (fig. 1, *r.o.*) internal to, but on a level with the last gill (16). The duct runs from the opening round the outside border of the pallial nerve (fig. 2, *r.o.*), and then passes inwards to open into a bladder-like structure placed in the body cavity (fig. 1, D, and fig. 2, D). This bladder-like structure lies close to the body wall immediately beneath the pericardium (fig. 2, *p.c.*), and it does not seem to extend backwards beyond the last gill.

On a closer examination by means of sections, it is seen to be beset by a number of branched glandular cæca, lying in the hinder part of the body cavity (fig. 2, *h.t.*), which open into it, and into a backward prolongation from it (fig. 1, *h.k.*). These branched glandular cæca on opening the body cavity are seen as a mass of tubes apparently interlacing with those of the opposite side, and lying ventral to the

* Schiff, "Zeit. f. Wiss. Zool.," Bd. ix.

† "Morphol. Jahrbuch," Bd. iv.

FIG. 1.

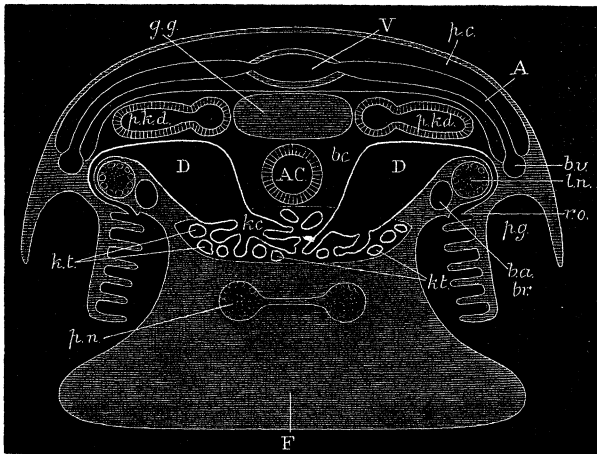


A diagrammatic representation of the kidney and generative ducts of *Chiton discrepans*, viewed from the ventral surface. The pallial groove is represented as enclosed by the lines *p.g.*; and in it are seen the 16 gills (*br.*), the generative (*g.o.*) and renal (*r.o.*) orifices; and the anus (*a.*) The branched nature of the kidney is shown in the anterior part of the figure on the right side; posteriorly these secreting tubules are omitted. On the left side of the figure the kidney duct alone is indicated.

a., anus; *br.*, branchiæ; *D*, dilated part of kidney duct opening to exterior; *g.* points to the junction of the generative duct with the generative gland; the generative gland is supposed to be torn away; *g.d.*, generative duct; *h.k.*, posterior part of kidney duct; *g.o.*, generative orifice; *k.t.*, secreting tubules of kidney; *k.d.*, duct of kidney running forward, bending round at *T* and running back, receiving glands as far back as *O*. From *O* it runs to the pericardial opening *p.o.*, receiving no glands; *p.g.*, pallial groove; 13, 14, 15, 16, last four branchiæ; the ventricle and auricular openings are indicated by dotted lines.

rectum on the floor of the body cavity (fig. 2, *k.t.*). This portion of the kidney has been seen and described by von Jehring, but instead of constituting the whole of the kidney and opening to the exterior by a median pore, it is only the posterior part, and opens on each side into the bladder-like structure which opens to the exterior in the

FIG. 2.



A diagrammatic representation of a transverse section through *Chiton discrepans* at the level of the renal orifices (*r.o.*, fig. 1). Dorsally is the pericardial cavity with the heart, separated by the pericardial floor from the general body cavity (*b.c.*), containing the viscera. Ventrally is the posterior apparently median unpaired part of the kidney (*k.t.* and *k.c.*) seen by von Jehring. A little in front of this section, the kidney tubules take up a distinctly lateral position.

D; *p.g.*; *b.r.*; *k.t.*; *r.o.* as in fig. 1.

A, auricle; V, ventricle; *b.v.*, branchial vein; *b.a.*, branchial artery; *p.c.*, pericardial cavity; *l.n.*, lateral nerve (pallial); *p.n.*, pedal nerve; F, foot; A.C., alimentary canal; *g.g.*, generative gland; *b.c.*, body cavity; *k.c.* see *k.t.*; *p.k.d.*, part of kidney duct which in fig. 1 is hidden from view by D.

position described above. I have many series of sections through this hinder part of the kidney of *Chiton*, which prove most conclusively that these hinder ventrally placed tubules do open in the way I have stated.

On examining the anterior end of the bladder-like structure it is found that it is continued forwards as a duct (fig. 1, *k.d.*), which receives, all along its course, the ducts of bunches of branching glandular cæca, lying at the side of the body cavity (fig. 1, *k.t.*). These branching glandular cæca constitute the gland described by Middendorff. Their structure precisely resembles that of the first described

posterior tubules, which open into the dilated part of the duct and its backward prolongation. The duct can be traced forward to about the level of the 4th shell-plate (fig. 1, T), at which point it turns sharply round and runs back parallel with the first part of its course. A considerable part of the gland lies in front of this turning point of the duct; the secretion of this part is poured into a branch given off from the main duct at the bend (fig. 1, T). The posteriorly directed part of the renal duct lies close to the dorsal edge of the part running forward, and, like the latter, receives the efferent ducts of bunches of glandular cæca (fig. 1). From the level of the 5th shell-plate (fig. 1, O) to its posterior termination (fig. 1, *p.o.*), about to be described, it receives no glandular cæca, but runs backwards as a simple duct distinguishable by its brown colour, which is due to a deposit of colouring matter in its walls. On reaching the level of the bladder-like dilatation of the kidney duct first described, it applies itself to the dorsal inner wall of that structure as far back as the level of the last gill. At this point, which marks the hind border and the external opening of the bladder, it runs outwards and then forwards (fig. 2, *p.k.d.*) in close contact with the dorsal side of the lateral nerve cord. It runs forward to about the level of the penultimate gill, where it suddenly stops and opens by a small pore into the pericardium (fig. 1, *p.o.*) beneath, *i.e.*, ventral to the anterior part of the auricle.

Comparing the arrangement of the kidney of Chiton with that of Anodon, there is seen to be a close agreement. In both the kidney is paired and consists of a gland bent on itself, opening at the one extremity into the pallial cavity, and at the other into the pericardium. In both the kidney is unsegmented (a fact to be remembered when the nature of the shell and gills of Chiton is discussed). There is a further agreement between these two animals in the relation of the openings of the generative ducts to those of the renal ducts; in both the latter are placed close behind the former.

With regard to the minute structure of the kidney of Chiton, I have no exact observations. It is necessary to study it in the fresh state. The inner borders of the cells lining the glandular cæca are stated by von Jehring to be ciliated.

The most internal part of the kidney duct, *i.e.*, that which receives no glandular cæca (fig. 1, O to *p.k.d.*), is, with the exception of a small portion adjoining the pericardial opening, lined by columnar cells containing a yellow colouring matter, which gives this portion of the duct a yellow colour, easily visible to the naked eye. This yellow colouring matter, which seems to be part of the excretion of the cells lining the duct, is absent in the part of the duct which runs forwards from the level of the hinder edge of the bladder to the pericardial opening (*p.k.d.* to *p.o.*). Here are found large columnar cells provided with long cilia, which line also the pericardial opening.

The cells of the glandular cæca seem to have the structure usually seen in molluscan renal organs, and have been correctly described by von Jehring.

To sum up, the kidney of *Chiton* consists of—

(1.) A duct opening to the exterior in the pallial groove behind the generative opening, and internally into the pericardium.

(2.) Glandular cæca opening into this duct.

The duct may be described as consisting of three parts:—

(1.) The part into which the glandular cæca of the kidney open. This part is open behind where it opens to the exterior (fig. 1, D). In front it bends round (fig. 1, T), and runs backwards to about the level of the 5th shell-plate, where it changes its character, and is continuous with (2) a duct (fig. 1, O) containing brown colouring matter in the columnar cells lining it, and receiving no glandular cæca. This part extends back to the level of the last gill, where it turns outwards, and becomes continuous with (3) a part running forward for a short distance close to the lateral nerve, and lined by large ciliated columnar cells. This part opens in front at the level of the penultimate gill into the pericardium (fig. 1, *p.o.*). I expected to find the communication between the two parts of the renal duct behind in the region of the bladder, and for some time I was puzzled at not finding it. On mentioning the arrangement of parts to Mr. Balfour, he suggested that the communication might possibly be found in front, reasoning from the analogy of the structure of the kidney in other Mollusca. On examining the anterior part of the gland more carefully, I at once found that his suggestion was correct, the two parts of the gland communicating as I have described. I have no observations to add to those of previous observers, on the general arrangement of the nervous system. I may mention that the lateral and pedal nerves have a coating of ganglion cells, and a central core of fibres.

The animals are diœcious. The generative gland is unpaired and dorsal. The generative ducts are paired, and are attached to the hinder border of the gland, and open in *Chiton discrepans* into the pallial groove between the 13th and 14th gill, in a line with the opening of the renal duct. The duct passes dorsal to the anterior end of the dilated part of the renal duct (fig. 1, *g.d.*); and then curls round the outer border of the lateral nerve-cord to its opening, presenting in this respect precisely the same relation as does the renal duct. The male duct has a short direct course to its opening (fig. 1); while the female duct is much coiled.

Another species, *Chiton cancellatus*, which I have examined, presents essentially the same arrangement of its renal organ and generative ducts as that just described for *Chiton discrepans*.

Dall* states that in some species of *Chiton*, the generative products

* "Proceedings of the United States' National Museum," vol. i.

escape into the body cavity and make their exit by several pores placed close together, and symmetrically, on each side in the pallial groove; oviducts apparently being absent. I have not any specimens of the species he mentions as possessing this peculiarity (*e.g.*, *Chiton marmoreus* and *ruber*), so have not been able to test his observations by means of sections.

I hope to be able to give a fuller account of these and other points in the anatomy of *Chiton* at some future period, for the preparation of which it will be necessary to obtain some fresh specimens.

VI. "The Action of Cutting Tools." By A. MALLOCK. Communicated by Lord RAYLEIGH, F.R.S. Received November 4, 1881.

The action of cutting tools has not often been treated from a theoretical point of view; in fact I only know of two papers on the subject, one by Professor Willis and the other by Mr. Babbage. Of these Professor Willis's paper is purely geometrical, showing what angles the edges of tools may make with one another if the cutting angles are to be such as experience shows to answer best. Mr. Babbage, on the other hand, does not enter at all on the question of the shape of the tool, but by making certain assumptions as to the relation between the dimension of the shaving removed by a tool and the work required to remove it, he deduces some results showing how to remove a given amount of material most economically. His conclusions cannot be considered correct, nor do they agree with experience (see Note 1). I do not attempt in the following paper to give any dynamical investigation of the action of tools, in fact it would be almost impossible to do so without a more extended knowledge of the laws which govern the strains in bodies subjected to large forces, but merely to classify the various actions which observation shows to be caused by the progress of the tool, and to quantify approximately the work expended in each. For this purpose, shavings from a great variety of substances were examined both in the course of their formation (by a microscope attached to the toolholder) and after they were removed.

Among the substances examined may be mentioned four or five samples of wrought iron, and as many of steel, cast iron, gun metal, brass, copper, lead, zinc, hard paraffin, soap, and clay.

This last-mentioned substance was found extremely useful in examining the formation of the shavings, for by altering the amount of water it contained its behaviour under the tool could be made to

FIG. 1.

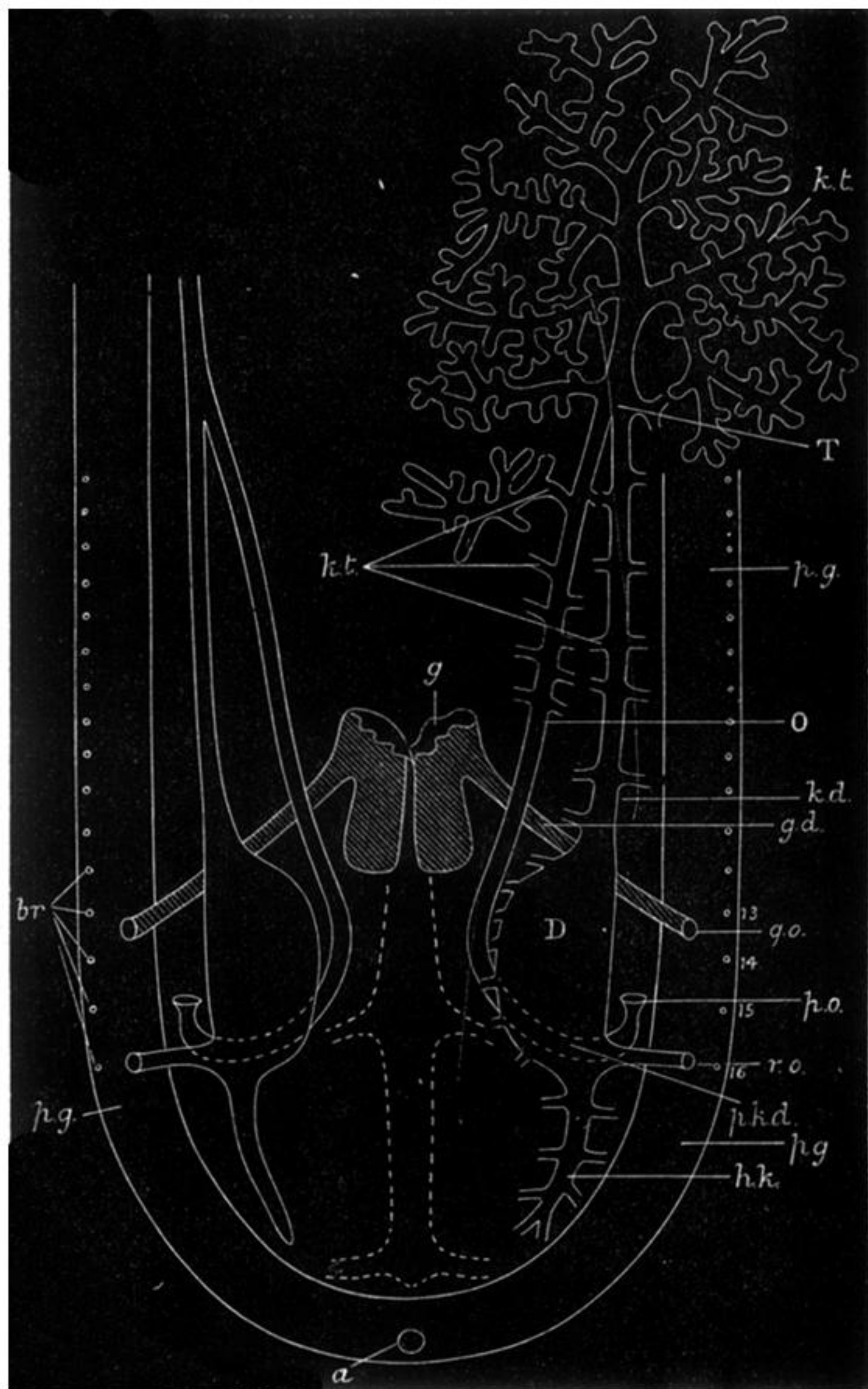


FIG. 2.

